Power quality issue is becoming more and more important for electricity consumers at all levels of usage due to the disturbances introduced by nonlinear loads and increase in number of sensitive equipments. Reactive loads such as fans, pumps etc. draw lagging power factor currents and therefore, give rise to reactive power burden in the distribution system. Non-linear loads such as static power converters and power electronics based equipments create considerable harmonic pollution in the distribution system. Source currents are non-sinusoidal and imbalance in magnitude due to non-linear unbalance load. These currents produce non-linear voltage drops across the feeders, which result in pollution in the voltages at the supply point of the utility [1]. Hence, power quality is deteriorated due to proliferation of non-linear and lagging power factor loads [2-4]. The situation becomes more critical when there is a flow of excessive neutral current which causes problems such as wiring failure, transformer overheating and malfunctioning of electronic equipments [5]. Therefore, it is essential to analyze and compensate the unbalance, harmonic and reactive components of the load currents under various source voltage conditions.

Standard regulations and recommendations of IEEE-519 enforce the limit on the aforementioned power quality problems [6]. To alleviate these power quality problems, some remedies are reported in the literature [7-9]. The concept of custom power was introduced by Hingorani in 1995 [10]. Custom power is the technology which utilizes power electronics components in power distribution systems. It provides an integrated solution to many power quality problems encountered by the utilities and power distributers. With the help of this technology, the utilities can supply value-added, reliable and high quality power to its customers. The proper use of this technology will benefit all the industrial, commercial and the domestic customers.

Shunt active filter is an active filter which is connected in shunt with the load. It regulates current injection into the system very efficiently using power electronics based control. Shunt

active filter is used to eliminate the harmonic currents into the distribution system. Distribution static compensator (DSTATCOM) is power electronics based shunt compensator. It injects currents in the distribution system at the point of common coupling (PCC) to provide load balancing, active filtering and power factor correction [11]. This mode of DSTATCOM operation is termed as current control mode.

The major consideration in the performance of DSTATCOM is the control strategy used for extraction of reference compensator current components. Several control techniques for reference compensator current generation are reported in the literature. These control techniques are based on indirect current control theory, p-q-r theory, application of neural network, PI controller based algorithm, instantaneous symmetrical component theory, Adaline-based control algorithm, instantaneous reactive power theory, synchronous reference frame theory and instantaneous active and reactive current component theory [12-23]. Most of the techniques give satisfactory performance under balanced sinusoidal source voltage condition. Though, behaviour of DSATCOM has already been analysed under balanced and sinusoidal environment, less work have been reported for its behaviour during non-ideal source voltage conditions with different load conditions.

The main objective of this thesis is to develop an effective reference current generation technique for DSTATCOM which satisfy following points under various source voltage and load conditions.

- It cancels the effect of poor load power factor.
- It suppresses the effect of harmonic content in load currents and restricts THD of source currents as per IEEE-519 standard.
- It overcomes the effect of imbalance in load currents.
- It eliminates source neutral current due to unbalancing of load currents in case of three-phase, four-wire distribution system.

- It mitigates reactive power from source.
- It compensates zero sequence power from source due to imbalance in source voltage as well as load current in case of three-phase, four-wire distribution system.
- It diminishes apparent power supplied from source.

In this research work, load compensation of star and delta connected load in three-phase three-wire as well as three-phase four-wire distribution system under various source voltage conditions has been evaluated. Furthermore, in addition to ideal source voltage conditions, non-ideal source voltage conditions such as unbalanced sinusoidal, balanced distortion and un-balanced distorted source voltage conditions have also been taken into account.

Research has been carried out to achieve the above mentioned aims and the major contributions of the thesis are summarized as under.

1. The first stage of present research work deals with the development of versatile reference current generation technique for DSTATCOM for three-phase, three-wire and three-four wire distribution system under ideal as well as non-ideal source voltage conditions. Linear and non-linear load connected in star or delta configuration has been considered in the above developed scheme. The proposed scheme has been applied for load compensation of delta connected load using DSTATCOM in three-phase, three-wire distribution system. Linear as well as non-linear balanced/unbalanced load has been taken into account. The performance of the proposed scheme has been evaluated under balanced sinusoidal, unbalanced sinusoidal, balanced non-sinusoidal and unbalanced non-sinusoidal source voltage conditions. The simulation results indicate that the proposed scheme is capable to provide harmonic compensation, imbalance elimination, power factor correction and source VA reduction under various source voltages and load conditions. In addition, the proposed scheme is capable to restrict THD of source current within IEEE-519 standard harmonic current limits under any condition.

2. The effectiveness of appropriate control strategy for DSTATCOM to enhance power quality under ideal as well as non-ideal source voltage conditions is demonstrated. Linear and harmonically polluted balanced/unbalanced load connected in star configuration in three-phase, three-wire distribution system has been considered. The performance of the proposed control strategy has been compared with instantaneous reactive power theory (IRP) and instantaneous symmetrical component theory (SC). These three control strategies for a DSTATCOM are analyzed and critical comparison between three approaches is evaluated. A proposed method has resulted improved performance of DSTATCOM under non-ideal source voltage with various load conditions. Under ideal source voltage condition, all three control strategies converge to similar results. It was shown that IRP strategy and SC strategy are susceptible to harmonic contamination and imbalance in the voltages at PCC. In IRP and SC theories, any attempt to improve power factor and balancing of source currents deteriorates THD under non-ideal source voltage conditions. Proposed control strategy is capable to restrict the THD of the source current as per IEEE-519 standard harmonic current limit along with the reactive power compensation, source current balancing and reduction in apparent power under various operating conditions of source voltage and load. Simulation results indicate that the proposed control strategy is generalized in nature and able to compensate the linear and nonlinear load under any kind of source voltage condition.
3. The dynamic performance of DSTATCOM with proposed control strategy has been evaluated in three-phase four-wire distribution system under ideal as well as non-ideal source voltage conditions. Star connected linear as well as harmonically polluted load has been considered. To ascertain the viability of the proposed control strategy, a comparative evaluation is of the proposed scheme is also carried out with IRP and SC theories. The performance has been evaluated under various operating conditions of source voltage and

load. Under ideal mains conditions, these three control techniques give almost similar results whereas they give dissimilar results under unbalanced sinusoidal and non-sinusoidal source conditions. It has been observed that IRP and SC techniques are highly sensitive against distortion and unbalance in the voltages at PCC. Both IRP and SC techniques give source currents of equal magnitude but distorted in nature whereas proposed method provides balanced sinusoidal source currents. Further, the proposed technique is capable to restrict THD of the source currents as per IEEE-519 standard. The simulation results indicate that if one seeks compliance with harmonic standards, imbalance mitigation, source neutral current elimination, zero sequence power compensation and reactive power compensation, the proposed scheme is the only alternative as it takes corrective action under any source voltage and load conditions.

The present work is likely to contribute significantly to the area of power quality improvement. The different techniques developed will be particularly useful for DSTATCOM for three-phase, three-wire and three-four wire distribution system under ideal /non-ideal source voltage conditions as well as linear/non-linear/harmonically polluted balanced/unbalanced load connected in star/delta configuration. Some suggestions, based on observations and simulations in this area, are proposed at the end of the thesis for the benefit of potential researchers.

The proposed research work is divided into seven chapters.

Chapter 1: The first chapter deals with the introduction of the problem, basic requirements of the power quality and discusses importance of power compensating device. This chapter retraces the history of development of custom power devices from the first generation network reconfiguring type to the present, compensating type. This chapter emphasizes on the research opportunities in the area of harmonic mitigation along with power factor correction, load balancing and reactive power compensation under non-ideal source

voltage conditions. Moreover, it also shows direction for upgrading power quality in three-phase, four-wire distribution system by the virtue of source neutral current elimination and instantaneous zero sequence power compensation. It presents the relevant literature survey and motivation behind the research work carried out in the thesis.

Chapter 2: This Chapter provides the necessary background on DSTATCOM, and operating principle and realization of DSTATCOM when connected in a power distribution system. The basic compensator scheme for star and delta connected load has been discussed.

Chapter 3: This chapter discusses the proposed reference current generation technique. The proposed technique has been used for power quality improvement in three-phase, three-wire as well as three-phase, four-wire distribution system. Linear/non-linear load connected in star or delta configuration under ideal as well as non-ideal source voltage conditions has been considered.

Chapter 4: This chapter address the simulation results of proposed control strategy applied for load compensation of delta connected load in three-phase, three-wire distribution system. Linear as well as non-linear balanced/unbalanced delta connected load has been considered. The performance of DSTATCOM has been evaluated under balanced sinusoidal, unbalanced siunsoidal, balanced distorted and unbalanced distorted source voltage conditions.

Chapter 5: This chapter demonstrates the application and validation of proposed control strategy for power quality improvement of star connected load in three-phase, three-wire distribution system. Linear and harmonically polluted balanced/unbalanced star connected load has been considered under ideal as well as non-ideal source voltage conditions. To evaluate relative performance, the proposed control strategy is compared with existing control strategies with reference to IEEE std-1459 power definitions.

Chapter 6: This chapter presents the performance of DSTATCOM with the proposed reference current generation technique for star connected load in three-phase, three-four wire distribution system. To demonstrate the viability of proposed reference current generation technique, it is compared with the existing reference current generation techniques with reference to IEEE std-1459 power definitions. It is assumed that the system is polluted due to the presence of loads that may be unbalanced and draw harmonics. Balanced as well as unbalanced sinusoidal and non-sinusoidal source voltage conditions have been considered.

Chapter 7: This final chapter presents conclusion of the work and highlights the contributions made by the author. Some suggestions for carrying out further work in the area of power quality improvement have also been proposed.

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Author's Contribution in terms of Research Papers

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1. Tejas Zaveri, B.R.Bhalja, and Naimish Zaveri, "Simulation and Analysis of Control Strategies for DSTATCOM ", International Journal on Control System and Instrumentation, ACEEE, Vol. 1, No. 1, pp.No. 116-120,July 2010, ISSN No.: 2157-9997.

2. Tejas Zaveri ,B.R.Bhalja, and Naimish Zaveri," A novel approach of reference current generation for power quality improvement in three-phase, three-wire distribution system using DSTATCOM", International journal of Electrical Power and Energy Systems, Elsevier,Vol.33,No.:10,December 2011, pp.No:1702-10.
3. Tejas Zaveri , Bhavesh Bhalja, and Naimish Zaveri," Load compensation using DSTATCOM in three-phase, three-wire distribution system under various source voltage and delta connected load conditions", International journal of Electrical Power and Energy Systems, Elsevier,Vol.41, No.1, October 2012, pp.No.: 34-43.
4. Tejas Zaveri , Bhavesh Bhalja , and Naimish Zaveri , "Comparison of Control Strategies for DSTATCOM in Three-Phase, Four-Wire Distribution System for Power Quality Improvement under Various Source Voltage and Load Conditions",In Press , International journal of Electrical Power and Energy Systems, Elsevier ,.

Papers Presented in Referred International Conferences

1. Tejas Zaveri ,Bhalja Bhavesh, and Naimish Zaveri,"Control Techniques for Power Quality Improvement in Delta Connected Load using DSTATCOM " , IEEE International Electric Machines & Drives Conference (ISBN No.:978-1-4577-0060-6), 15 - 18 May,Canada, pp.No:1419-24,2011.

Article Published in National Magazine

1. Naimish Zaveri, Tejas Zaveri, Ajitsinh Chudasama, Bhavesh Bhalja , " Importance of power quality in Electrical Distribution System: A case study of South Gujarat region " , Electrical India(RNI. Reg.No. 6226/61),Vol. 49,No.11, November 2009, pp.182-7.

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1. Tejas Zaveri , Bhavesh Bhalja , " Versatile Reference Current Generation Technique for Power Quality Improvement of Delta connected load using DSTATCOM under various Source Voltage Conditions ", International Journal of Energy, Elsevier.

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